

Non-deforming, high-reflectance X-ray coatings for Lynx and other future missions

Completed Technology Project (2018 - 2021)



Project Introduction

The overarching challenge addressed by this proposal is the development of high-reflectance, high-resolution X-ray mirrors, to be used for the construction of lightweight X-ray telescopes for future NASA astronomy missions such as Lynx and others. The proposal's two specific aims are: 1) the development of optimized iridium-based interference coatings for the 0.1–10 keV band; and 2) the development of methods to mitigate coating-stress-induced substrate deformations in thin-shell glass and Si mirror segments. These goals will be achieved by building on established film deposition techniques and metrology infrastructure for X-ray optics that have been developed and advanced by the PI through APRA funding since 1999. Specific Aim #1: Interference Coatings for the 0.1–10 keV Energy Band Telescope effective area can be maximized by using Ir-based reflective coatings that exploit optical interference to provide higher reflectance than Ir alone. However, only preliminary investigations of such coatings have been conducted thus far; more research is required to fully optimize these coatings for maximum performance, to experimentally determine the coating designs that are feasible, and to determine the achievable X-ray reflectance, film stress, surface roughness, and thermal and temporal stability. The first specific aim of this proposal is to reach these very goals through a comprehensive research program. Demonstration of the achievable reflectance, stress, and roughness in stable, optimized coatings will in turn facilitate global telescope design optimization, by identifying the best coating for each mirror shell based on incidence angle, and on telescope effective-area and field-of-view requirements. The research has the potential to greatly increase the effective area of future X-ray telescopes. Specific Aim #2: Mitigation of Coating-Stress-Induced Substrate Deformations High-quality films of Ir and other candidate materials (e.g., B₄C) to be investigated for the 0.1–10 keV band deposited by magnetron sputtering have high density and low roughness, and thus good X-ray performance. However Ir, B₄C, and certain other materials have exceedingly high film stress when deposited under conditions for maximum reflectance. Residual film stress in the X-ray reflective coatings can deform thin-shell mirror segments, leading to unacceptable degradation of angular resolution. Coating stress was not an issue for Chandra. But for Lynx, for example, the substrates will be ~50x thinner, and so sub-arc-second resolution simply cannot be achieved using thin-shell mirror segments without the development of non-deforming coatings. The second specific aim of this proposal is to develop techniques to mitigate coating-stress-induced deformations in glass and Si shell segments. Two potential solutions will be investigated: a) New deposition methods to control coating thickness uniformity and net film stress in two dimensions will be used to determine if already-developed zero-net-stress Ir-based coatings, as well as the new reflective coatings to be developed, can be deposited onto shell segments without inducing unacceptable substrate deformations, a question that has not yet been definitively addressed; if uniform coatings having sufficiently low deformation cannot be realized, then non-uniform coatings will be investigated, where spatial control of net film stress in 2D will



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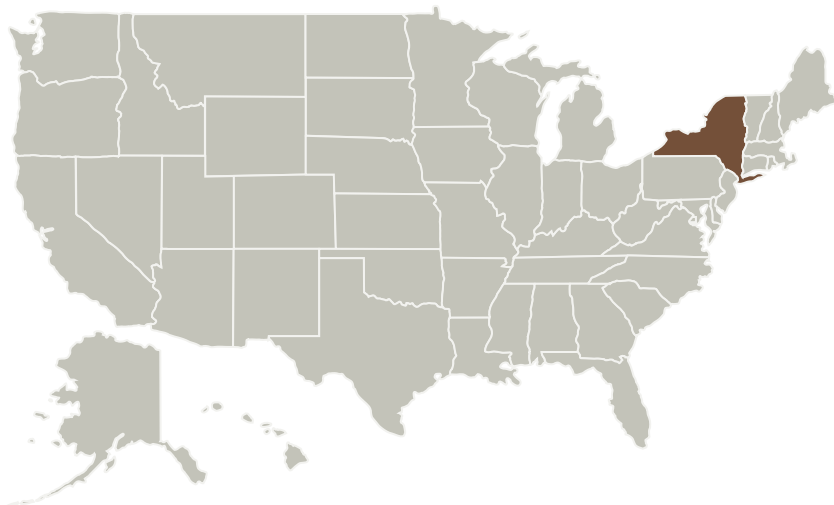


compensate for potential non-uniform deformations. If successful, the effectiveness of the approach with more complex interference coatings will also be established. b) A more general (albeit more complex) method of mitigating stress-induced deformations will be investigated, specifically the use of balanced front- and back-side coatings, a technique that, if successful, can be used, in principle, with any type of coating (Ir-based, high-energy multilayers, etc.), regardless of its stress state. (The approach is likely incompatible with active correction, however.)

Anticipated Benefits

The Astrophysics Research and Analysis program (APRA) supports suborbital and suborbital-class investigations, development of detectors and supporting technology, laboratory astrophysics, and limited ground based observing. Basic research proposals in these areas are solicited for investigations that are relevant to NASA's programs in astronomy and astrophysics, including the entire range of photons, gravitational waves, and particle astrophysics. The emphasis of this solicitation is on technologies and investigations that advance NASA astrophysics missions and goals.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Reflective X-Ray Optics LLC	Lead Organization	Industry	New York, New York

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Reflective X-Ray Optics LLC

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

David L Windt

Co-Investigator:

David L Windt

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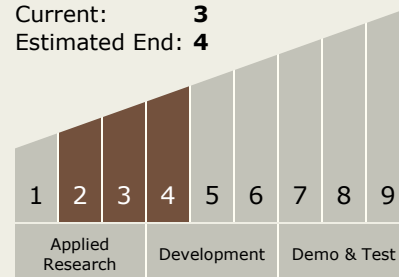


Primary U.S. Work Locations

New York

Technology Maturity (TRL)

Start: 2
Current: 3
Estimated End: 4



Technology Areas

Primary:

- TX08 Sensors and Instruments
 - TX08.2 Observatories
 - TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System